Friday, December 04, 2015
8:45 AM

Gravitational Potential Energy Worksheet solutions

Question one

Because of Earth's rotation

a) the earth bulges in the centre like a spinning water balloon, since F_g is proportional to $1/r^2$, if r increased F_g decreases

b) the spin of the Earth makes you feel slightly less apparent weight because the centripetal acceleration is towards the centre of the Earth, therefore F_N (apparent weight) is less than F_g. (Like being on top of a roller coaster hill, for example. The inertia keeps you moving tangentially to the circular path) spin at equator causes $0.03 m/s^2$ variation.
North pole 9.83 equator 9.78
0.03 by spin, 0.02 by r

Question Two

T=102 minutes = 102x60=6,120 s

$g=a_c=4\pi^2 r/T^2 = 4\pi^2(3.43x10^6)/(6120s)^2$

$g=3.62$ N/kg $= F_g/m$

Question Three

T=27.3days = 27.3x24x3600= 2358720 s

$g=4\pi^2 r/T^2 = 4\pi^2(3.8x10^8 m)/(2358720 s)^2$

$a=2.7 \times 10^{-3}$ m/s^2

Question Four

$a_c=v^2/r=9.81 m/s^2$

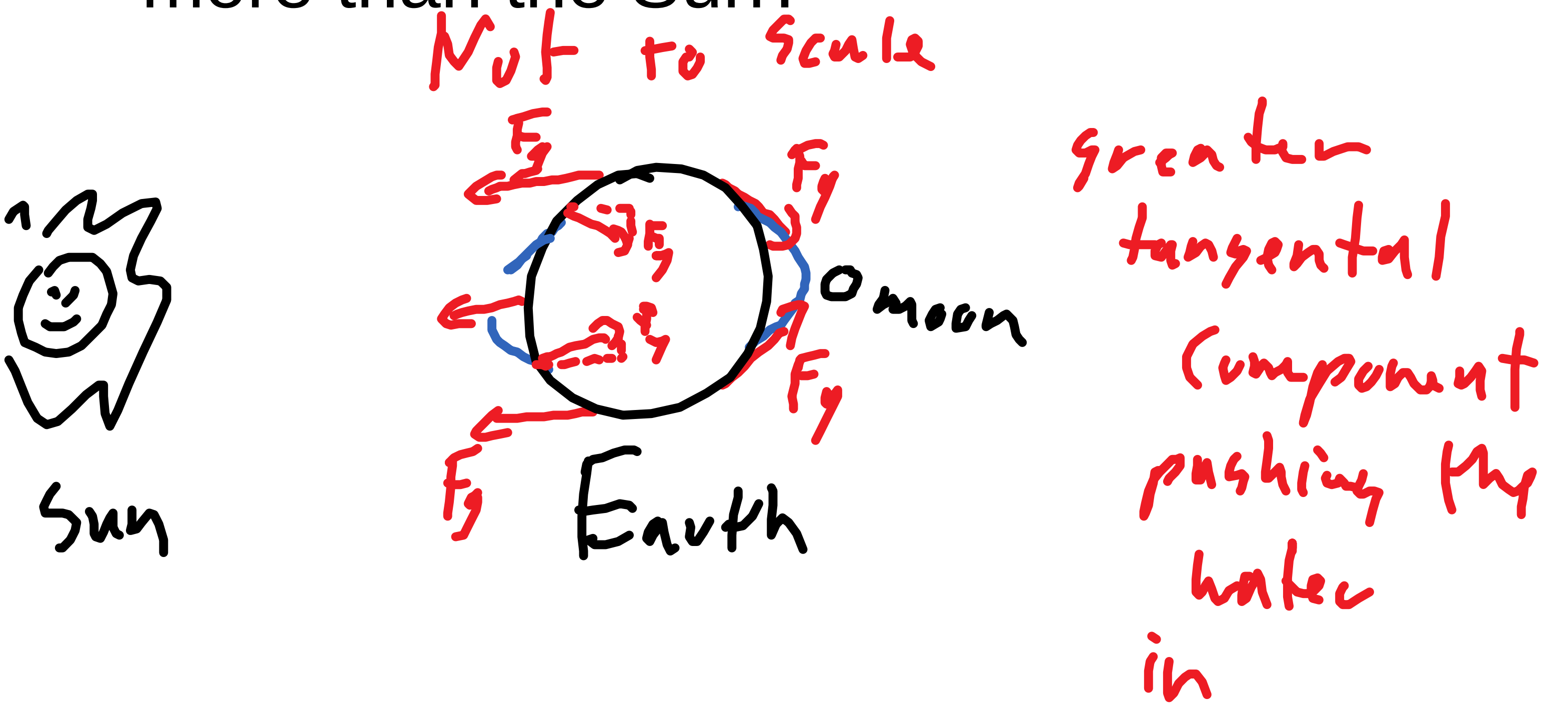
$$v=\frac{\sqrt{(9.81\frac{m}{s^2}\times 6.38\times 10^6 m)}}{\square}$$

$v= 7.91x10^3$ m/s

Question Five

T=365.25 days = 365.25x24x3600= 31557600 s in a year

$g=4\pi^2 r/T^2 =$
$4\pi^2(1.5\times10^{11} m)/(31557600\ s)^2$
$= 5.9 \times 10^{-3} m/s^2$ you don't feel this as you are in freefall to the Sun.
Note the Earth's acceleration towards the moon is way smaller than towards the Sun.
Why are tides affected by the Moon more than the Sun?



Six
much smaller $2.7\times10^{-3}/5.9\times10^{-3}$

Question Seven
a,b,c same

d double

Question Eight

$Eg = - GMm/r =$

$-6.67 \times 10^{-11} Nm^2/kg^2 \ (5.98 \times 10^{24} kg)$

$(1kg)/6.38 \times 10^6 m$

$= -6.25 \times 10^7 J$ relative to zero at infinity

Question Nine

solution using Earth's field only

$Egf = - GMm/r =$

$-6.67 \times 10^{-11} Nm^2/kg^2 \ (5.98 \times 10^{24} kg)$

$(1kg)/3.8 \times 10^8 m$

$=-1.05 \times 10^6 J$

Using the moon's field, set Egi=0

Egf=

$-6.67 \times 10^{-11} Nm^2/kg^2 \ (7.35 \times 10^{22} \ kg)$

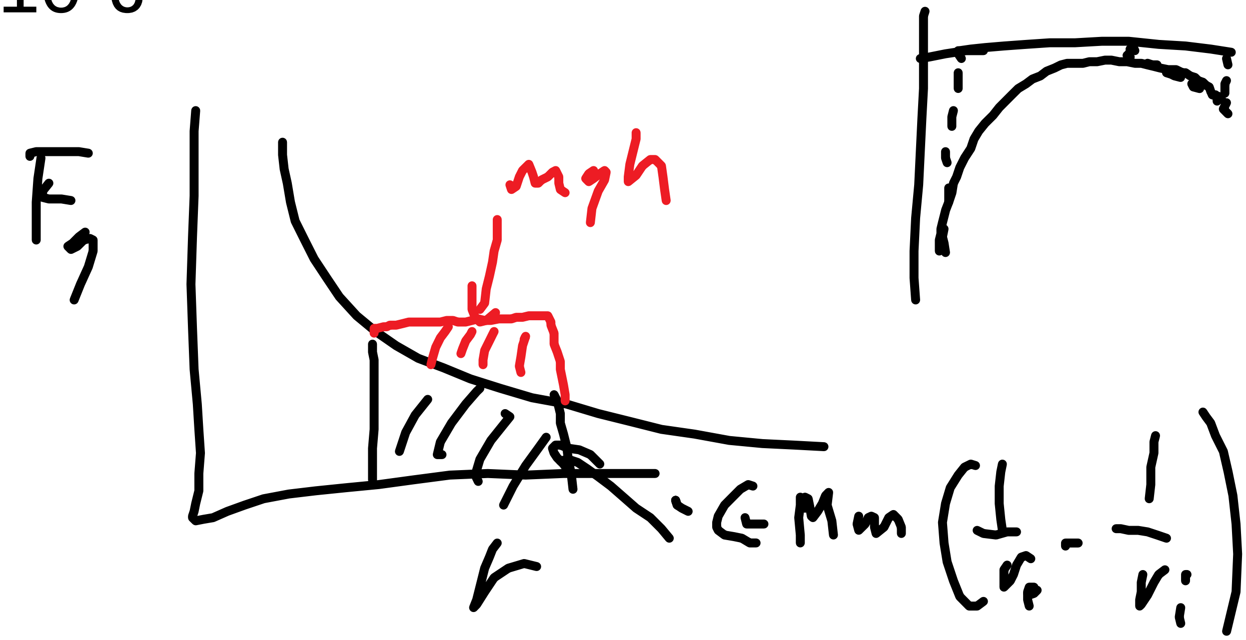
$(1kg)/\underline{1.73 \times 10^6 \ m} = -2.83 \times 10^6 J$

radius of moon

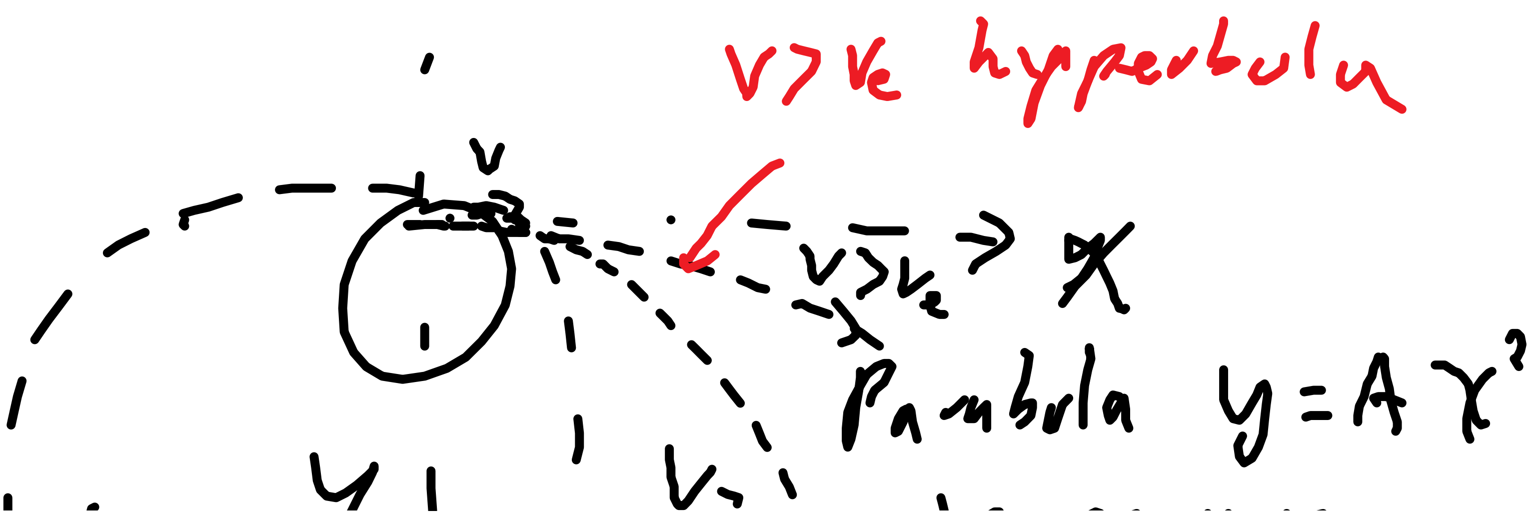
ignore Sun's field

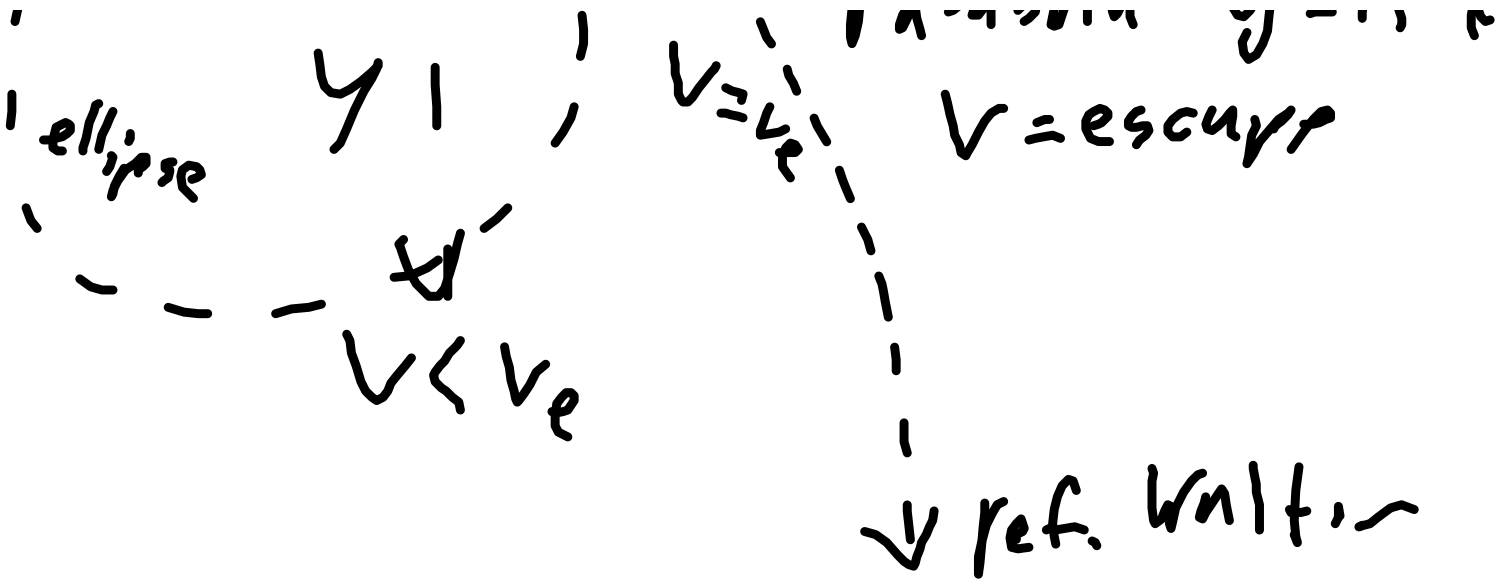
$\Delta Egt = (Egf+Egf) - Egi$

(-2.83x10^{6}J -1.05 x 10^{6}J) - (-6.25 x 10^{7}J)
5.86x10^{7}J



Question ten
|Eg|=Ek
v= root 2GM/r
root(2 x -6.67x10^{-11}Nm^2/kg^2 (7.35x10^{22} kg)/1.73 x 10^6 m)
= 2.38 x10^3 m/s





Question eleven
Eg Earth

$Eg = -GMm/r =$
$-6.67\text{x}10^{-11}\text{Nm}^2/\text{kg}^2\ (5.98\text{x}10^{24}\text{kg})$
$(1000\text{kg})/6.38\text{x}10^{6} = -6.25 \text{ x } 10^{10}\text{J}$
relative to zero at infinity

Moon
$-6.67\text{x}10^{-11}\text{Nm}^2/\text{kg}^2\ (7.35\text{x}10^{22}\text{ kg})$
$(1000\text{kg})/1.73 \text{ x } 10^{6}\text{ m} = -2.83\text{x}10^{9}\text{J}$

ratio = 62.5/2.83=22.0848 times more energy to escape Earth than moon ignoring air resistance

Question Twelve

escape speed = c

$R = 2GM/c^2 = 2(6.67x10^{-11}Nm^2/kg^2)(1.99x10^{30}kg)/(3.00x10^8m/s)^2$

$= 2.95$ km

Question Thirteen

$E_{binding} = GMm/2R$

$(6.67x10^{-11}Nm^2/kg^2)(1.99x10^{30}kg)(5.98x10^{24}kg)/ 2(1.50 \times 10^{11}m)$

$2.65 \times 10^{33}J$